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Brief Communication: First Evidence of LSAMAT in Non-Native Americans: Historic Senegalese From West Africa

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ABSTRACT To date, the distinctive dental wear pattern known as LSAMAT, or "lingual surface attrition of the maxillary anterior teeth," has been documented in prehistoric samples from Brazil, Panama, and Puerto Rico only. However, new data from a historic Senegalese sample reveals the first example of this wear pattern outside the Americas. The Senegal LSAMAT is present in 45% of 22 adult crania, and is associated with a caries rate of 40% in 38 adults (6.7% of 534 permanent teeth). A correlation between LSAMAT and caries was also observed in the Latin American samples. In these cases, it was hypothesized that LSAMAT was caused by the specialized consumption of an abrasive, high carbohydrate food, such as manioc. Manioc is a common cultigen in Senegal; thus, it may have also caused the African LSAMAT. The chewing of sugar cane could have been an additional, contributing factor. Am J Phys Anthropol 102:141–146, 1997.

In several previous articles, an unusual tooth wear pattern on the lingual surfaces of anterior maxillary teeth was described in prehistoric samples from Brazil, Panama, Puerto Rico (Turner and Machado, 1983; Irish and Turner, 1987; Turner et al., 1991), and perhaps Texas (see Comuzzie and Steele, 1988). Macro- and microscopic striations are often present on the affected teeth, running from the cingulum to the occlusal surface (see SEM photograph in Turner et al., 1991). There is no corresponding wear on the anterior mandibular teeth. This wear pattern is termed "lingual surface attrition of the maxillary anterior teeth," or LSAMAT (after Turner and Machado, 1983). It is defined as the progressive wearing with age of upper anterior lingual tooth surfaces without corresponding lingual or labial wear on the lower teeth. In individuals with extreme LSAMAT, upper premolars and even first molars can exhibit lingual wear (Turner and Machado, 1983). The pattern does not result from erosion (see Robb et al., 1991; Turner et al., 1991), occlusal overbite, overjet, malocclusion, or other anatomical considerations.

The LSAMAT frequency ranges from 85% of adult crania at the Archaic Corondó site in Brazil, to 57% at the late prehistoric Venado Beach site in Panama. LSAMAT was also observed in prehistoric crania from Cerro Mangote, Panama (see Irish and Turner, 1987), and Punta Candelero, Puerto Rico (Turner et al., 1991; Crespo, 1994). To date, it has not been observed in deciduous teeth. In all of these Latin American samples, the wear pattern is associated with a high caries rate, ranging from 60% of adults at Corondó (11% of all permanent teeth) to 82% at Venado Beach (11.7% of permanent teeth).

The LSAMAT/caries combination suggests a diet high in some type of abrasive,

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carbohydrate-rich food, such as manioc (*Manihot utilissima, Manihot esculenta,* Crantz). This starchy tuber has been grown in Mesoamerica and South America for perhaps the past 3,000 to 4,000 years (Roosevelt, 1980; Cock, 1982, 1985).

Manioc roots must be peeled before consumption (Onwueme, 1978). The inner layer contains mostly water, starch, and glucose. In "sweet" varieties (see Discussion), this layer has a pleasant, sugary taste when eaten raw (Grace, 1977; Cock, 1982). If LSAMAT was indeed caused by consuming manioc, it could only have occurred through long-term shredding or sucking of raw, peeled, potentially grit-laden roots between the upper teeth and tongue. Modern cultivators often consume raw manioc for the taste and moisture content (Grace, 1977). Moreover, several fresh manioc roots, obtained from a Brazilian farmer near the Corondó site (see Turner and Machado, 1983), had the perfect diameter to produce LSAMAT.

The purpose of the present report is to describe the first occurrence of LSAMAT in a dental sample outside the Americas—historic Senegalese from West Africa. The Senegal dental wear is identical to the LSAMAT previously observed. In addition, the African dentitions exhibit a notable caries rate. The wear/caries combination again suggests the consumption of abrasive, carbohydrate-rich food(s). Coincidentally, manioc has been a common food crop throughout Senegal and the rest of West Africa since its introduction in early historic times. Sugar cane (*Saccharum* sp.), a high carbohydrate crop unavailable to the prehistoric Latin Americans, is also grown in some areas.

MATERIALS AND METHODS

The dental sample examined in this study is from Senegal, in extreme West Africa. Most of the country consists of a low, rolling tropical savanna, which is notably drier than the wet tropical forests to the south (Hart, 1982; Lye and Carpenter, 1987; Future Vision Multimedia, 1995). The sample consists of 38 historic crania (M = 20, F = 14, ? = 4) reckoned to be from the Wolof (n = 32), Serer (n = 3), and Balante (n = 3) tribes. The exact geographic provenience of several crania is unknown, although most Wolof and Serer were recovered near Dakar and St. Louis. Members of the Balante tribe currently live in the Casamance River region of extreme southwestern Senegal. Thirty-seven of these well-preserved crania are curated at the Musée de l'Homme, Paris; one is at the National Museum of Natural History in Washington, DC. Most of the Musée de l'Homme specimens (n = 24) were recovered during the late 19th and early 20th centuries (AD 1873–1910). The remaining crania, although collected between 1953–1964, are apparently from a similar period. The National Museum of Natural History cranium is undated.

The Wolof, Serer, and Balante tribes have had substantial contact with one another through time and have very similar material cultures (see Gamble, 1957; Murdock, 1959). Further, Greenberg (1966) notes that they exhibit significant linguistic similarity. He classifies all three into a Senegambian Group of the West Atlantic subfamily of the Niger-Congo language family. These peoples are agriculturalists who, since historic times, have grown a variety of food crops, including millet, maize, yams, rice, and manioc (Thomas, 1860; Aujas, 1929; Pedler, 1951; Senghor, 1960; Johnston, 1963). In addition, some sugar cane may be grown in the wetter regions (Winterbotham, 1944; Pedler, 1951; Nolan, 1986).

The dentitions of 42 Senegalese crania were originally used in a dental morphometric study of African origins and relationships (Irish, 1993). This investigation demonstrated that most specimens possess a combination of both North and Sub-Saharan African dental features. However, they are more closely aligned with samples from the latter geographic region. Data from 38 of the most complete dentitions are used in the present study; they are described and, in several cases, compared to one another using non-parametric chi-square tests.

RESULTS

Of the total 38 adult Senegalese crania, 22 retain anterior teeth for dental wear analysis. Of these 22 dentitions, 10 (45%) display characteristic LSAMAT (Fig. 1), typified by wear on the upper anterior lingual tooth surfaces without corresponding wear on the

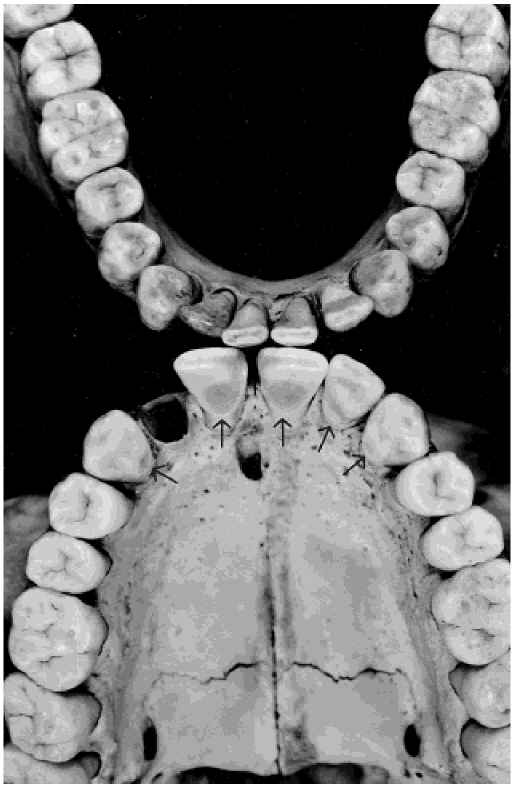

Fig. 1. Arrows point to LSAMAT (exposed dentine) on upper central incisors, extant lateral incisor, and both canines in adult Senegalese female. The lower teeth exhibit slight wear on the occusal surfaces only.

TABLE 1. Frequency of LSAMAT in Senegal crania

	With LSAMAT	Without LSAMAT
Males (n = 12)	41.6% (5)	58.4% (7)
Females (n = 8)	50.0% (4)	50.0% (4)
Unknown sex (n = 2)[1]	50.0% (1)	50.0% (1)

[1] Twenty-two out of 38 total crania have anterior dentitions to allow analysis for LSAMAT.

lower teeth. In addition, macro- and microscopic striations (as visible in the SEM photo in Turner et al., 1991) are present, running from the cingulum to the occlusal surface of affected teeth.

The raw percentage of LSAMAT in the males (42%) is lower than in the females (50%) (see Table 1). However, the difference in the small sample is not significant (χ_1^2 [Yates] = 0.23, $P > .5$). In addition, because only adult crania are present, we are unable to correlate sample-specific LSAMAT severity with age. For all maxillary anterior teeth (incisors and canines) in both sexes, the percent with LSAMAT is 33% (24 of 73 total teeth). Of these 73 teeth, the central incisors are affected 48% (11 of 23 teeth) of the time, the lateral incisors 25% (5 of 20 teeth), and the canines 27% (8 of 30 teeth) of the time. In addition, 17% of first premolars (6 of 36 teeth) exhibit slight lingual wear. There is no analogous wear on the remaining upper posterior teeth.

TABLE 2. Frequency of caries in Senegal crania

	With caries	Without caries
Males (n = 20)	45.0% (9)	55.5% (11)
Females (n = 14)	35.7% (5)	64.3% (10)
Unknown sex (n = 4)	50.0% (2)	50.0% (2)

Forty percent of the Senegal crania (15 of 38) exhibit caries (Table 2). When broken down by sex, nine of the 20 males (45%), five of the 14 females (36%), and two of the four specimens of unknown sex (50%) have at least one carious lesion. For those crania with LSAMAT the overall caries rate is 41% (9 of 22 individuals). Thus, like the Latin American samples, there is some degree of association between the two conditions. This is illustrated by the lack of a significant difference between Senegal LSAMAT and caries frequencies ($\chi_1^2 = 2.06$, $P = .15$). Regarding individual teeth, 36 of 534 total teeth in the sample are carious (6.7%). All others are missing either ante- (n = 66) or postmortem (n = 600±). Of the 36 extant carious teeth, four are from the anterior (2 upper canines, 2 upper central incisors) and the rest are from the posterior dentition.

DISCUSSION

The most readily apparent differences between the Senegal and Latin American samples are the prevalence rates of LSAMAT and caries: both are lower in the Africans (45 vs. 57–85%, and 40 vs. 60–82%, respectively). A two-sample chi-square test between the African and (pooled) Latin American samples reveals that these differences are significant (LSAMAT $\chi_1^2 = 6.46$, $P = .01$; caries $\chi_1^2 = 24.61$, $P = .00$). Such variation may be the result of several factors. First, it could simply represent an artifact of sample size and completeness; the

small Senegal sample is missing many teeth ante- and postmortem. It is probable that some of these teeth, particularly those missing antemortem, had been carious. Similarly, numerous missing and heavily worn maxillary anterior teeth (n = 137) do not allow scoring for LSAMAT. Second, the lower Senegal dental wear/caries rate may indicate a reduced dependence on abrasive, carbohydrate-rich food. Third, unlike the site-specific Latin American samples, the Senegal crania come from two broad regions of the country. Such geographic heterogeneity may have played a role in the diet type. For example, unlike a rural setting, individuals in urban areas would not have had access to highly perishable foods like manioc and sugar cane (Jones, 1959; Roosevelt, 1980; Cock, 1985; Galloway, 1989). Whatever the reason(s), the Senegal sample does exhibit LSAMAT. Moreover, the caries rate, although lower than in the Latin American cases, is close to that for pre-industrial agriculturalists world-wide (Turner, 1979; Turner et al., unpublished data).

There have been a few alternative hypotheses to explain the occurrence of "lingual anterior maxillary tooth wear" and other LSAMAT-like patterning (e.g., Albrethsen et al., 1976; Comuzzie and Steele, 1988; Hartnady and Rose, 1991; Robb et al., 1991). Indeed, we previously acknowledged that some alternate explanations cannot be completely ruled out (see Irish and Turner, 1987; Turner et al., 1991). However, we maintain that LSAMAT, as described above, most likely results from the consumption and/or oral processing of an abrasive, carbohydrate-rich food. And, like the Latin American samples, we suggest that the food which caused the Senegal LSAMAT may have been grit-laden manioc (*Manihot utilissima, Manihot esculenta,* Crantz). Manioc was first introduced in West Africa by the Portuguese some 400 years ago (Thomas, 1860; Jones, 1959; Johnston, 1963; Cock, 1985; July, 1992). Since the 1800s, the tuber has been an important food crop throughout Senegal and the rest of West Africa (Thomas, 1860; Chevalier; 1930; Pedler, 1951; Jones, 1959; Senghor, 1960; Johnston, 1963; Papadakis, 1966; de Wilde, 1967; Onwueme, 1978; Hart, 1982; Cock, 1985; Nolan, 1986; July, 1992; M. Gessain, personal communication, 1992).

To many West Africans, manioc constitutes a primary food crop. Consumption of up to 1 kg of the tuber per day, per adult, is not uncommon (Jones, 1959; Cock, 1985). To others, manioc is primarily a famine reserve in case of grain or other crop failure (Pedler, 1951; Papadakis, 1966; Nolan, 1986). Feast or famine, manioc is a common cultigen because it produces a high caloric yield, grows well in poor soils, is drought and disease resistant, and requires very little labor (Jones, 1959; Papadakis, 1966; Hart, 1982). As such, in the St. Louis area of Senegal during the 1950s, up to 12% of the land used to grow food crops was planted in manioc (Jones, 1959).

As noted, LSAMAT is specifically thought to result from long-term shredding or sucking on raw manioc roots between the upper teeth and tongue. A raw root primarily consists of water (65%) and starch and glucose (32%) (Cock, 1985; Johnston, 1963). It is a good source for niacin, vitamin C, calcium, and calories. However, it lacks protein, and can lead to malnutrition if the diet is not supplemented (Jones, 1959; Johnston, 1963; Roosevelt, 1980; Hart, 1982). Manioc also contains toxic hydrocyanic (prussic) acid (Jones, 1959; Grace, 1977; Roosevelt, 1980; Cock, 1982, 1985). In a continuum from "sweet" to "bitter" varieties, higher levels of the acid are found in the latter. Bitter manioc can only be eaten after the acid has been removed (e.g., as in flours or meals) (Jones, 1959; Johnston, 1963; Grace, 1977; Cock, 1982, 1985). But Martial (1937), as quoted in Jones (1959, p. 190), states that bitter manioc is "little known," and sweet varieties predominate in West Africa. The "sweet" manioc varieties contain only small amounts of acid in the outer layers. Thus, the inner portion of the raw root has a pleasant, sweet taste (Grace, 1977; Cock, 1982).

Chevalier (1930, p. 676) relates that ". . . in Senegal [whole] manioc was eaten only raw or baked." Jones (1959) and Cock (1985) concur, and state that in Africa (and Brazil), roots of the sweetest varieties are sometimes eaten raw as a between-meal snack or thirst-quencher. Jones (1959, p. 103) further notes that in Africa, it is the ". . . custom in

some areas to plant the sweet varieties in the center of a field of bitter roots so they will not be pilfered by passers-by." In some African individuals, consumption of raw manioc is so high that they may suffer from chronic cyanide toxicity (Cock, 1985).

Another potential cause of the Senegal LSAMAT may be sugar cane (*Saccharum* sp.). Sugar cane was not present in prehistoric Latin America and could not have been an agent for LSAMAT there. However, like manioc, it was introduced into West Africa 400 years ago by the Portuguese (Thomas, 1860; July, 1992). Since that time, sugar cane has been cultivated in the wetter regions (Winterbotham, 1944; Pedler, 1951), like southeast Senegal (Nolan, 1986). More widespread cultivation of sugar cane in West Africa only became possible with irrigation. Thus, since the 1960s it became an important export crop in Senegal (Senghor, 1960; Future Vision Multimedia, 1995).

Like manioc, sugar cane is high in water (80%) and, of course, sugar (16%) in the form of sucrose (Vandercook, 1939; Galloway, 1989). As such, stems of raw sugar cane are often "chewed" as "a pleasant refreshment" by the people who grow it (Winterbotham, 1944, p. 455; Galloway, 1989, p. 62) or by those who buy it in local markets (Papadakis, 1966; de Wilde, 1967). It is consumed in a manner similar to that suggested for raw manioc. That is, a section of peeled cane is shredded or sucked on between the upper teeth and tongue. In addition, the diameters of stems range between 2.5 to 5.0 cm (1–2 inches) (Thomas, 1860; Galloway, 1989), which is an ideal size to produce LSAMAT.

However, despite its potential to produce LSAMAT, there is a problem in implicating sugar cane as a principal cause of wear in the Senegal sample. Much of the northern half of the country, where >90% of the sample is from, is semiarid. To illustrate, the St. Louis area receives about 380 mm (15 inches) of rainfall per year (Future Vision Multimedia, 1995). Unlike manioc, sugar cane requires abundant moisture (Galloway, 1989). It cannot grow in such a dry environment without the aid of irrigation. Moreover, in 1929 Aujas reported that near Dakar, sugar cane is ". . . not cultivated very much—the soil is not suitable—with rare exception" (Aujas, 1929, p. 119). It is only in the past 30 years that sugar cane has commonly been grown in the Dakar/St. Louis region (Future Vision Multimedia, 1995), with irrigation on large farms and/or plantations that can afford the necessary labor force (Vandercook, 1939; Papadakis, 1966; Galloway, 1989). Thus, the turn-of-the-century Senegal dental sample pre-dates the proliferation of sugar cane in the region as seen today.

In conclusion, the dental wear pattern known as LSAMAT has been found in a historic sample from Senegal. This is the first example of the wear pattern outside the Americas. LSAMAT is associated with dental caries in all cases. We maintain that LSAMAT results from the extensive, specialized consumption of an abrasive, high carbohydrate food. In Latin America this food may have been manioc. In the Senegalese example the wear/caries agent may also have been manioc, and/or perhaps sugar cane. Of the two plants, manioc would have been the most common cultigen at the time where individuals of the Senegal sample were alive.

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